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and cables connecting the vessels with the dock. All gangways are guarded by watchmen while down. Prior to loading all vessels are fumigated to destroy rats, sulphur being burned to make a 4 per cent sulphur dioxide gas in the spaces fumigated. All general freight shipped overland and oversea is inspected to ascertain whether there is a possibility of its harboring rats or mice.

Foci of plague, both human and rodent, are being treated by evacuation, that is, removal of the inhabitants; by fumigation of all buildings; and by deratization by the summary destruction of rat-harboring places, intensive trapping and poisoning, and enforced rat proofing.

Passed Assistant Surgeon Creel has been made executive officer in charge of the working force. Surgeon Corput is in charge of measures applied to outgoing vessels. Passed Assistant Surgeon Simpson is in charge of the field work in the city. Assistant Surgeon Williams is in charge of the laboratory. That portion of the city bounded by Canal Street, Claiborne Street, Louisiana Avenue, and the river has been divided into three districts, to be placed in charge of Assistant Surgeons Kearny, Carmelia, and Akin. July 10 the inspection of the bodies of all persons dying in the city was begun. This inspection is made daily between the hours of 6 and 9 p. m.

The force making the rodent survey consists of 188 men engaged in trapping. They have in use 12,779 traps, which they are systematically setting throughout the suspected district and adjoining territory. Gangs of men have been started distributing rat poison. A laboratory has been fitted up and the laboratory examination of the rats trapped is in full force. On July 16, 1,039 rats were caught. The number of rats being caught is increasing at the rate of about 100 daily. The residents of the city are being informed of the nature of the situation and the necessity for their frank cooperation. This is being done through a publicity campaign and daily addresses at meetings. Effective rat-proofing laws have been drafted and submitted to the city authorities for enactment.

## BUBONIC PLAGUE.

### ITS ERADICATION AND PREVENTION IN URBAN COMMUNITIES.

By R. H. CREEL, Passed Assistant Surgeon, United States Public Health Service.

Discussion will be confined to a consideration of the bubonic type of plague only, with but a passing reference to the pneumonic form of the disease, and city infection will be considered as apart from rural.

From the viewpoint of eradication there is no similarity between the pneumonic and the bubonic forms of plague. The term "pneumonic plague" is misleading; it should more properly be designated "plague pneumonia." Epidemiologically it is a highly contagious pneumonia and eradication is based on the assumption of aerial transmission. The secondary pneumonia sometimes observed in bubonic plague is not a true plague pneumonia. It is not productive of secondary cases of plague.

Plague in country districts (which in the United States is equivalent to squirrel plague) and the pneumonic form of the disease in man are both subjects that merit special and separate consideration.

The eradication of bubonic plague in theory is an easy task, but a thoughtful review of the stupendous efforts exerted by the United States Public Health Service in connection with local health organizations in exterminating the disease from various parts of United States territory during recent years will attest the fact that the theory and practice of plague eradication are widely divergent. The maintenance of infection foci in so many parts of the world year after year despite sanitary measures lends ample confirmation that plague infection is one of the most resistant to elimination, one of the most tenacious of all epidemic diseases. The particular striking aspect of plague infection is the tenacity with which the infection among rodents will cling to a locality.

This condition obtains seemingly irrespective of social or climatic environment or geographic location.

*Partial suppression.*—In civilized communities suppression of human case incidence is not so difficult. Let any enlightened people know that plague has gained entrance among them and the efforts of the citizens will greatly advance the work of the sanitary officials in cutting down the rat population, and human cases seem to cease when the rodent population is reduced 50 per cent or thereabouts. This was noted in San Francisco and more recently in Porto Rico. This cooperation, though, will continue only so long as there are human cases. On the cessation of human cases, even though the infection among rodents may be unaffected or even increasing, the cry will go up, "Plague is over; let us quit," and quit they do. It is the same in all countries where plague infection causes commercial prejudice or works a hardship in business affairs. So it follows that plague suppression and plague eradication are two different procedures. It is therefore imperative that antiplague work accomplished in the first days of a threatened epidemic, when popular opinion is strongly indorsing all sanitary measures, should be of as permanent a nature as possible. Rat proofing can not be instituted too soon or enforced too vigorously. Legal requirements should be enacted at once and should be clearly defined and devoid of ambiguity or loopholes.

*Quiescent rodent infection.*—It is this factor of indifference of the community to plague infection among rodents as long as there is no human case that is largely responsible for the persistence of the infection. As a matter of fact plague infection in man when of the bubonic type is only of humanitarian interest. Plague being primarily a disease of rodents, the entire procedure of eradication embraces the rat and its parasites, and human case incidence can be ignored in pursuing a plan of campaign. Too often does the status of human cases serve as an index of the presence of infection in the absence of a proper survey of the rodent population. A number of places can be cited where suppressive measures were enforced only so long as human cases occurred. On the subsidence of human infection the work dragged and finally ceased; the infection continued in rodents, and a recrudescence followed sooner or later. This has happened notably in Trinidad and in different South American countries, Ecuador and Venezuela and Peru, in the Canary Islands and in the Orient.

### Organization.

*Special corps.*—Plague work is more efficiently done when performed by a special corps of men who are not distracted by other sanitary duties. The work is too important and too exacting to be made a part of the routine duties of a general sanitary corps. The men in immediate charge of the campaign should be entirely free to devote all their time and attention to plague work.

Of primary importance in organizing the force is the installment of a special plague laboratory.

### Laboratory.

*Laboratory site.*—The site of the building is important. It should be well isolated but not too remote for convenience of access. When large numbers of rodents are being examined some of them will arrive at the laboratory in a putrid condition, and the odor alone would preclude the maintenance of the laboratory in the near vicinity of dwellings or other occupied buildings. Exclusion of flies is very necessary for the comfort, if not the safety, of the workers. It should be well screened and both rat proof and flea proof, the floors of concrete, well drained and kept wet with kerosene or kerosene emulsion.

It should be especially well lighted with ample window space and, if necessary, a skylight.

*Laboratory equipment.*—A maximum amount of daylight is a prerequisite in studying the gross lesion of rodents, especially in observing the finer granulations in the liver. A plentiful supply of water should be available and gas connections secured. An elaborate equipment is unnecessary as the cultural study of plague is of minor importance, a scrutiny of the gross lesions of the dissected animal and animal inoculation comprising the most important part of rodent plague diagnosis.

The table for manipulation of rat cadavers is very important. It should be of ample dimensions raised in the center and sloping to the edges, covered by zinc and well guttered at the circumference. The surface of the table at all times is to be thoroughly drenched with a pulicidal solution.

An animal room with a large supply of guinea pigs and white rats should be adjacent to the rodent morgue, preferably in a separate building. Animal inoculation and inoculated animals are to be confined to the morgue and all inoculated animals are to be kept in a flea-proof receptacle. As a further precaution no animal should be inoculated for diagnostic purposes except it be first thoroughly cleansed of fleas. Especially does this apply to captive wild rats.

*Diagnosis of rodent plague.*—The article in Public Health Bulletin No. 30 by Surg. G. W. McCoy on the laboratory diagnosis of plague is so thorough in every way that further remarks on the subject are superfluous, but too much stress can not be laid on the injunction to beware of making a diagnosis of plague in rats through the examination of the smear alone. The provisional diagnosis of rat plague from a scrutiny of the gross lesions is justifiable when one is well versed in the subject, but it must be remembered that the tissues of a dead rat very soon become contaminated with putrefactive bacilli of the colon group, and stained smears not infrequently show bipolar bacilli and cause grave errors when any dependence is laid upon this diagnostic procedure. Koch's postulates should always be adhered to in making a diagnosis of plague in rodents. The diagnosis of human plague should likewise be confirmed by animal inoculation, but the appearance of a typical bipolar-bacillus in a stained preparation that has been obtained from a bubo of a living patient can be accepted as strongly presumptive of plague infection.

*Importance of laboratory.*—The laboratory is the very foundation of a plague campaign. Upon the efficiency of its corps in detecting rodent plague depends the movements of the field force. A knowledge of the progress of the epizootic, its decline, and cessation, all depends on the bacteriologist. The laboratory report is the guide relied upon to redouble efforts in new foci, the barometer that indicates the effectiveness of eradicative measures, and, finally, the evidence upon which is based the decision as to the successful issue of the campaign.

Each day a report should be forwarded from the laboratory to the headquarters containing various data, chiefly the location where plague rodents have been found and the number of rats examined, with an enumeration of the species. It is a great aid to the field work to know the location of different species, the predominance of any one species in certain parts, the fluctuation of flea infestation of rodents as indicated by a flea survey, variation of breeding season, etc.

Having established a laboratory, the next logical step is the formation of a corps of trappers, who, while cutting down the rat population, will provide material for the laboratory.

### Demarcation of Infection.

*Ascertainment of foci.*—The earlier the confines of the rodent infection are charted out, the sooner will the sanitarian appreciate the magnitude of the work before him. A "spot" map will be of great aid in determining the progress of the infection or its resistance to eradicative measures in any given area.

An approximate idea of the extent of rodent plague in a city or town may be obtained from the laboratory examination of captured rats, but this is not always satisfactory. Even by intensive trapping the percentage of rodent infection as determined from laboratory reports is at times quite low, varying from 0.2 per cent to 2 or 3 per cent, while at the time a fairly high human case incidence seems to controvert the estimate of rodent infection as indicated by laboratory findings.

*Use of "control" animals.*—Heretofore the delimitation of the epizootic zone has been effected by examination of rats, and in practice this will always be the chief reliance, but if guinea pigs or captive rats (white or wild) are available a very effective supplemental measure can be utilized. This consists in placing "sentinel" pigs or rats at varying intervals throughout the district. Such animals should be confined in a spacious cage and a sanitary inspector be delegated to make daily observation of their condition. If large numbers of animals be used, the provisional distribution would be on the basis of four animals per block in separate cages and posted in four principal rat centers of the block.

This procedure, so far as the writer knows, has never been attempted. As a means of determining rodent plague foci simultaneously and quickly over a large area, the method has very obvious advantages over the plague rat census. The efficiency of captive guinea pigs in determining infection in individual houses where human plague has occurred has been demonstrated so often that there is no question as to the practicability of the scheme. Five hundred animals would be sufficient to survey 125 blocks. If, after a week's exposure, the animal were well, it could be transferred to other territory and the test repeated.

The detection of rodent plague foci is at best haphazard. Undoubtedly many plague-infected rats die in burrows or under cover, where they are never found. Often when found dead they are thrown in garbage or burned by the householder, especially so when active eradicative measures are being enforced and the discovery of an infected rat means inconvenience to the neighborhood. This plan of survey of plague foci with guinea pigs seems to the writer very practicable and possessed of perfectly obvious advantages.

*Epidemiology of human cases.*—An epidemiologic study of human cases is likewise necessary and is an aid in fixing infected foci. The location of human infection is not always clear. Quite frequently the site of infection is the residence, but in Cuba the first 15 cases all apparently acquired their infection at places of employment.

One case in point in the Cuban epidemic of 1914 is interestingly illustrative of the difficulty sometimes attendant upon determining the source of human infection.

The man worked in a wholesale grocery house, slept in a house some distance from employment, and ate in a restaurant well removed from his place of employment and his living quarters.

A case of a few days previous had likewise taken his meals at the same restaurant, and it was thought that the restaurant was a focus of infection. Upon suggesting it to the director of sanitation he had placed in the grocery store eight guinea pigs. These "control" animals were exposed for overnight and then removed in order that the place could be fumigated. Within four days three of the animals died of plague. The experiment would have been more complete had "control" pigs been also placed in the living quarters of the patient and in the restaurant, but as there was no evidence of rat infestation at either place and the epidemiologic considerations all pointed to the grocery house this was not done.

Cases may occur where neither the residence nor place of occupation is the source of infection. Cases have been observed by the writer where the disease could only be ascribed to infection in the street or district casually visited by the patient.

*Doubtful focus.*—When a case of human plague occurs far removed from any other known case, it is very clear that it is important either to prove or disprove the new focus, for in an epidemic there is always work to be done both urgent and important, without performing needless measures.

Epidemiologic study may be strongly presumptive either for or against a new focus, but the use of "control" pigs should clear up doubt.

### Eradicative Measures.

*Regional measures.*—While intensive measures are generally confined to infected blocks, eradicative measures should be applied to the entire community, whether it be a small town or a large city.

To consider only a part of a town as infected because human case incidence is confined to any one quarter will often lead to the grave mistake of regional eradication. It should be borne in mind that as a rule the epizootic precedes human plague 10 days or two weeks, and at the time human infection occurs plague rats may be widely dispersed. When it has been determined that any instance of human infection is of indigenous origin and not an imported case, the wisest course will be to consider the whole community as infected territory and institute measures accordingly.

### Trapping.

*Scope of trapping.*—Foremost in point of importance in antiplague work is the destruction of rodents, and of the direct methods, trapping is the chief. Trapping serves double purpose. It reduces rodent population and it provides material for the laboratory.

Much has been written about trapping—the pattern of trap, the kind of bait, and the methods of trapping; but after all has been said and done it still remains probable that success in trapping is proportional to the attention and industry the trapper devotes to his traps; this and the protection of other food supplies from rats.

*Cage versus snap trap.*—Two kinds of traps are generally used, the wire cage trap and the snap trap or deadfall. Surgeon V. G. Heiser has made comparative tables of the number of rodents caught in cage traps and in snap traps, which demonstrate that snap traps in Manila are more productive of results.

The writer's observations are in accord with Heiser's tabulation, but his deductions are not. Almost without exception rat trappers are ashamed of their occupation. This seems to be especially so in people of latin origin. They do their duty in a manner as little productive of publicity as possible. To carry a cage trap through the streets is to widely proclaim their vocation, but the transfer of small snap traps from one place to another can be accomplished without attracting attention by putting the traps in a pocket or wrapping them in newspaper. To obtain the best results traps must be well attended and frequently moved from one place to another. For the above stated reason and because moving the cage trap requires more effort than the small snap trap, the trappers generally neglect the care of the former and chiefly concern themselves with the latter. The writer has had opportunity of seeing among several hundred trappers a few anomalies who were conscientious in the discharge of their duties, and from such observation is of the opinion that the cage trap is very much more effective than the snap trap when the two patterns are given equal attention by the trapper.

Not infrequently the cage trap when properly attended, will, in one night, capture from 3 or 4 to 20 rodents.

The writer has seen as many as 30 rats in one large cage trap. The animals were literally packed in the trap so tightly as to be hardly able to move.

*Pattern of traps.*—Large cage traps 20 inches in length are very much more effective than the smaller ones. Both the snap trap and the cage trap should be substantially made and the latter should have the wire well reinforced. The placing of traps is important. They should be placed where rats have been accustomed to frequent for feeding purposes. Traps should be more or less concealed, the snap traps by scattering about them dust, flour, or corn meal, and the cage trap by pieces of sacking, straw, or rubbish, leaving only the opening free.

The prerequisite of successful trapping is that no food other than the bait should be available.

*Bait.*—Other things being equal, highly savory articles, as cheese and toasted bacon, will more quickly attract rodents than food without odor, but the idea that a rat can be enticed into a trap by the employment of bait more appetizing to him than the surrounding food supply is fallacious. It has been asserted that the rat is an epicure. While this is hardly true, rats in different localities do show marked preference for certain articles of diet. A rodent that frequents a grain warehouse is most successfully trapped by the use of grain as a bait; those that frequent meat markets are similarly most successfully trapped in those places by using different kinds of meat for bait; and, again, those rodents that are found in green groceries or where vegetables are kept are more easily captured by baiting the traps with vegetables.

The trapper should be careful to move his traps when the place has been "trapped out." One resourceful trapper was accustomed to determine this point by dusting a thin layer of flour over the floor of the building in which he had been trapping and to make careful observations for signs of rat tracks. When, following several successful nights of trapping in a place, he could catch no rats for several nights he employed this method for two or three nights, and if no rat signs were evident he moved his traps to "fresh fields." If rats were still present and barren trapping results continued, he changed the pattern of trap or commenced a rotation of bait or searched about to ascertain if the rats had access to other food supply. If the latter, the condition was corrected by rat proofing or other means of preventing rodent access.

The number of traps and trappers to be apportioned to a given territory is important. The writer believes that one trapper can efficiently attend to 30 cage and 40 snap traps. The distribution of territory per man will vary in amount according to the nature of the district.

*Distribution of traps.*—In the business district where there may be many rat centers and food depots, as groceries, bakeries, warehouses and meat markets, a large number of traps can be placed in a small area, whereas in the residence district the rat population is more scattered and a trapper can be assigned a greater area. There should be no duplication of labor. Each trapper should confine his work to a fixed district. A convenient and effective organization consists in assigning four trappers to one foreman, with a supervising inspector in charge of the entire trapping force. The foreman should be held responsible for the property intrusted to trappers, and it is his duty to see that trappers are properly discharging their duty. By keeping a daily record of the rat catch, both the supervising inspector and the sanitarian in charge of the work can at all times be informed as to the inefficiency of any trapper.

The total number of traps to be employed will vary with the locality. It is better to have a community "overtrapped" than "undertrapped."

For the city of San Juan, P. R., which has 50,000 inhabitants, 3,000 traps and 40 trappers were employed; 1,500 snap traps and 1,500 cage traps, 4 trappers under the direction of 1 foreman, with a supervising inspector over all the force.

The question of compensation is important. An efficient laborer will not work for bounty alone. If the entire compensation of the trapper is paid by a fixed wage there is no incentive for improvement. A combination of salary and bounty generally is productive of most efficient service by trappers, a moderate salary supplemented by a bounty of 10 cents per rodent.

In Porto Rico the laborer was paid a salary of 75 cents per day and given 10 cents for each rat trapped over a fixed number per week. A premium of $1 to $5 for each plague-infected rodent turned in by a trapper would also act as an excellent stimulus for increased efficiency.

### Poisoning.

Of poisons the chemical ones give best results. The biological products, which chiefly consist of culture of the bacillus typhimurium group, have not been successful. The attempt to produce among rodents an epizootic harmless to man has so far proven barren of results.

*Poisons.*—Preparations of arsenious acid or phosphorus (10 per cent in suitable bases, as cheese, meal, or glucose) are the most popular poisons in use. Strychnine placed inside pieces of food, or by impregnating grain with its solution, is used to some extent, as is plaster of Paris, in proportion of 1 part to 2 parts of flour. This forms enteroliths and ultimately kills the rodent.

All such poisons undoubtedly have a certain efficiency in ridding a place of rats, but whether by causing a migration or through actual destruction is sometimes difficult of determination.

At best poisoning is haphazard and uncertain. The effectiveness is always a matter of conjecture and there is doubt as to whether results compensate for labor expended.

In trapping, not only is the rat destroyed but also a large number of fleas, whereas in poisoning the parasites of the poisoned rat escape. Considering the uncertainty of results, poisoning would seem to be justified only when there is sufficient labor to perform such work without prejudice to the work of trapping.

*Labels.*—It is of the utmost importance that every rodent sent to the laboratory whether trapped or found dead should be properly labeled with the address of place from which the animal was taken. The inscription should be legible, the tag of a durable material and well fastened to a leg. The foreman of each squad should verify this each morning before the bag is turned in.

## Natural Enemies.

The employment of the natural enemies of the rat, such as dogs, cats, mongoose or weasels, is of doubtful value. At best it is only a feebly auxiliary measure. The writer has frequently seen places overrun with rats, notwithstanding the presence of the above-mentioned natural enemies. Undoubtedly some breeds of cats and dogs are better than others for rat-catching purposes, but the average domestic dog or cat is not a success in preventing rodent infestation. Mongoose have been used with only moderately successful results. They are predatory in other ways, being very destructive to birds, poultry, eggs, and small game. Instances have been observed of warehouses overrun with rats despite three or four mongoose. This animal apparently attacks the rat only for the purpose of food and if well fed will live in amity with the mus family.

*Flea carriers.*—Another fact that renders the use of natural enemies undesirable for rat catching is that of flea transference. Cats and dogs are generally flea infested and when thrown in proximity to infected rats may be carriers of infected fleas. The transmission of infection to people in this way has been observed by the writer. Thus the employment of cats and dogs for rat catching is accompanied by an element of positive danger.

*Shooting*—In some localities rodents can only be destroyed by shooting. This method was employed in Porto Rico for the destruction of rats in the swamp shrubbery, and has been used in Honolulu to destroy the tree rat.

*Clubbing.*—During the destruction of rat harborage rats can be killed by the laborers.

## Rat Proofing.

Rat proofing has a two-fold object, it excludes rats from harborage and food supply and it insulates man from rodent contact.

Without this procedure it is almost impossible to materially reduce the rodent population.

The Japanese authorities have depreciated the value of trapping and poisoning as an antiplague measure, contending that with the temporary reduction in rat population by these measures, the relatively increased food supply and harborage stimulated breeding and longevity of rat life to a compensatory degree. In this argument several eminent Indian authorities on plague agree, notably among whom was Maj. Morehead, who said "rat destruction is of doubtful value." Obviously it is true that partial rat destruction alone will provide more favorable conditions for propagation to the remaining population, but, if the harborage is destroyed and foodstuffs protected, the favorable conditions for breeding are eliminated. Without the general enforcement of rat proofing, antiplague measures are bound to be more or less temporary and decidedly unsatisfactory.

It is probable though that no sanitary procedure ever met with so much opposition to its enforcement as rat proofing, especially when only rodent plague exists without the presence of human infection.

The antagonism arises either from the financial inability of the unfortunate community or the sordid unwillingness of the property owner to make any expenditure that does not promise personal gain.

Some methods of rat proofing enhance the value of property, as when concrete floors and foundations are built, but elevation of a house, changing material of roofing, removing double ceiling or inner walls do not make for material improvement, and orders for such changes generally meet with bitter protestation.

*Rat-proofing law.*—No time should be lost, therefore, in the early days of an epidemic, when every suggestion of the sanitary authorities is eagerly supported by the community, of securing the enactment of a rat-proofing law. Legal advice should be obtained in drawing up the measure so as to prevent legal loopholes. The law should clearly specify the measures necessary in rat proofing buildings already constructed and those of future construction; the manner of rat proofing; the degree of elevation or nature of structural change; and when the latter it should specify the quality and quantity of material.

In rat proofing any building the following parts have to be considered: Ground area, walls, ceiling, garret, roof, dead spaces in general, certain underpinning in elevated construction of bamboo or hollow logs, ventilators, abandoned sewers, doors, windows, outside piping, water and sewage pipes, down spouts, wiring, and air or light shafts. By the omission of some small detail an otherwise rat-proof structure may become badly rat infested.

*Ground area.*—The rat proofing of the floors of buildings is secured either by elevation of the structure with the underpinning open and free or by marginal walls of concrete, stone, or brick laid in cement mortar sunk 2 feet into the ground, fitting flush with the floor above. The wall must fit tightly to the flooring and not merely extend to the joists or supporting timbers, as this would result in open spaces for the entrance of rodents.

*Food depots.*—Food depots are of the greater importance in rat proofing because they furnish both sustenance and shelter for rats. In this class of buildings are stables, meat markets, retail and wholesale groceries, bakeries, warehouses, docks, and wharves. These places are best rat proofed as to the ground areas by the construction of concrete floors and foundation walls. Untenanted as they are at nighttime, rats might well enter doorways or windows carelessly left open or be introduced concealed in merchandise, and gnawing through plank flooring obtain well-protected hiding and breeding places.

To render a large livery stable entirely rat proof is hardly practicable owing to the doors being open almost continuously, but rat proofing even in such buildings will destroy rat harborage and limit rat invasion to an occasional migratory rodent. With concrete flooring, foundation walls, and protected feed bins it is a comparatively easy task to maintain the building comparatively rat free.

Manure bins should be rat proof, a concrete pit, unless there is frequent disposal.

*Stables.*—In the Tropics horse feed is largely green forage with but little grain. The stable, though quite open, oftentime consisting of only roof and flooring, does not harbor or subsist many rats. Rat proofing of the floor areas, protected feed bins and feed cribs will generally suffice to prevent rat harborage. A practical rat proofing of the crib consists in building the crib with a flare from below upward zinc covered and fastened at bottom without connecting timbers at top.

Structures that are difficult to keep rat free even though structurally rat proof are storage wharves and large wholesale warehouses where immense quantities of provisions remain stored during long periods.

*Elevation.*—Rat proofing by elevation is chiefly applicable to small and medium size buildings. The intent is to have sufficient elevation, about 2 feet, so that the ground area beneath shall be as exposed and free from covert as unbuilt-upon land.

For more pretentious dwellings, where sufficient care can be exercised to prevent rodents from gnawing through plank flooring, a marginal rat-proof foundation wall will suffice.

*Double walls.*—Double walls with a dead space between should be avoided, or if used should be rat-proofed at top and bottom with heavy wooden timbers, 4 by 4 joists, or by a concrete fill. Attics should be well opened and kept free of dunnage or other refuge for rats.

*Roofing.*—Double ceiling should be avoided, especially so in basements. A roof that affords ample rat harborage is that of country tiles, often seen in the Tropics. Unless all interstices are filled with mortar, this material should be prohibited, galvanized iron, slate, or flat tiling being substituted. Boxed-in structures, such as uprights in roughly finished dwellings, plumbing, kitchen sinks, and sundry similar arrangements, often furnish rat harborage. Such boxing should be removed. In the Tropics the underpinning is often of bamboo, or of timbers with hollow interior, which offer favorable nesting sites for rats, especially the mus rattus and mus Alexandrinus. Porches and steps should be given the same consideration as the body of the house.

Miscellaneous openings, as light shafts, ventilators, and open windows, should be screened, preferably by 12-gauge wire screen with mesh not exceeding one-half inch. Abandoned sewers or drainpipes at times give access to rodents and should be protected. Water pipes, sewage pipes, downspouts, and telephone or electric light wires should be rat-proofed when so placed as to furnish possible ingress to rats. This is best accomplished by running such structures through a broad ledge or by the use of rat-proof shields such as used to guard ship lines.

*Garbage cans.*—The garbage depository must be given most careful attention. It should be of metal, preferably a galvanized-iron can, water-tight to prevent seepage which would attract rats, and should have a closely fitting lid. A can 2 feet in height without cover will not be proof against the incursion of rats.

The grounds around a building are to be devoid of rat harborage. Premises are to be kept clean and free of rubbish. Plank walks and plank covering for yards are to be avoided. Cinders or concrete are preferable for this purpose. If the latter material is used it should have marginal protection to prevent rodents from burrowing beneath.

Chickens, goats, hares, pigs, and such animals that are generally fed on table scraps ought not to be allowed within the city limits.

*Chicken yards.*—Chicken yards when so permitted may be rat proofed by a concrete wall at the periphery, sunk into the ground 2 feet or more, with one-half inch mesh wire netting covering the top and sides.

The top netting is necessary, as otherwise rats can easily climb the sides and enter the pen. The writer has personally observed the Norway rat (which is not a climber like the black rat) scale a piece of wire netting 3 feet high. The feat was so rapidly performed that a laborer purposely stationed at the spot was not quick enough in action to strike the escaping rodent.

Loose materials about the yard should be piled on platforms 2 feet high.

*Trees.*—In tropical countries coconut palms, mango and almond trees furnish provender for rats. Such trees can best be protected by a band of tin or galvanized iron encircling the trunk, 1 foot wide, placed at a height of 7 feet from the ground and tacked firmly to the tree trunk.

Vacant lots and unbuilt-upon land should be maintained free of rat harborage, the owner of the property being held responsible.

*City walks.*—City sidewalks must be rat proof just as those on private grounds. One of the worst cases of rat infestation ever noted by the writer was that of an old broken concrete city sidewalk that was unprotected by marginal walls. The rats had burrowed beneath the cement in all directions.

*City sewers.*—Some types of city sewers harbor many rats, especially the old brick construction. The sewers are the last structures to demand treatment. Sewer rats are very little flea infested, and there is no place in the city where a plague rat can die with so little danger to man as in the sewer. Nevertheless, city sewers must be rat proofed as an aid in the general antirat crusade. Simpson has very ably discussed this problem in the Public Health Reports of October 31, 1913, page 2283.

*Concrete.*—A rat-proofing law should provide a minimum standard for concrete, both as to quality and quantity of its component parts and the dimensions of the construction. The thickness of floors should not be less than 3 inches of concrete with a half-inch capping of cement, and of walls not less than 6 inches. Standard brands of cement, clean, sharp sand, and hard stone in proportion of 1:2:3, or as approved by a competent engineer, ought to be required in all concrete construction.

In issuing orders to householders for rat proofing all instructions should be written in detail as to structural reforms. Placing on the reverse side of rat-proofing notices a printed copy of the rat-proofing law, with penalty for noncompliance, is advisable as being gently suggestive.

### Restrictive Measures.

To prevent extension of the infection to other localities will require supervision of cargo carriers—ships, railroad cars, and overland cartage—and inspection and treatment of rat-carrying cargo, and baggage.

*Fumigation of ships.*—Ships touching at a plague port should always be fumigated prior to taking on cargo. Sulphur dioxide, 4 per cent, and funnel gases (chiefly carbon dioxide) are the two fumigants mostly utilized.

In the service work sulphur dioxide is chiefly generated by the "pot and pan method." Ships exceeding 15,000 tons ought to be provided with a sulphur dioxide generator, such as the Clayton apparatus. Sulphur fumigation of vessels that have holds filled with cargo is practically useless. To be effective, the vessel must be empty, bilges opened, dunnage properly disposed of, and dead spaces such as boxed-in piping or double sheathing freely exposed. Under such conditions a 4 per cent sulphur dioxide fumigation for 12 hours is very effective. The utilization of funnel gas, when a special device is available, is likewise very effective and is applicable to fumigation of cargo. The article by Grubbs and Holsendorf, in Public Health Report of June 20, 1913, is a very excellent and comprehensive exposition of the various details of sulphur fumigation. Subsequent to fumigation all possible safeguards must be adopted to prevent reentry of rats into vessels, by loading at a rat-proof wharf or in the open bay or having all mooring lines provided with rat guards and gangways raised when not in use.

*Railway cars and freight yards.*—Railroad cars should be rat proof, to the extent of having all breaks in floor or sides repaired, and double sheathing either removed or securely closed in. Freight yards should be thoroughly inspected and cars that are left standing on track overnight, either partially or wholly loaded, should be closed and sealed.

*Cargo treatment.*—All export merchandise that might harbor rodents, whether intended for shipment by ships, car, or overland cartage, ought to be either repacked or fumigated to kill rats. For fumigation of cargo without injury hydrocyanic-acid gas is the preferable fumigant.

*Dunnage.*—Ordinarily baggage of the traveling public is of no importance, but where there is a large emigration from a plague community of people taking with them old clothes, bedclothes, etc., a thorough fumigation of this class of baggage is desirable to kill fleas.

### Special Measures.

The occurrence of rodent plague or human infection necessitates the promptest possible treatment of the infected premises, which consists of evacuation, fumigation, and intensive rodent and flea destruction, followed by rat proofing.

*Infected buildings.*—The premises having been determined to be infected the occupants are removed, taking with them only the clothes they wear. All other raiment and bedclothes are to be left in the house for fumigation. If the place is a store, all merchandise is left undisturbed. The building, being hermetically sealed, is fumigated by sulphur, or by hydrocyanic-acid gas. The latter is especially indicated when the treatment is applied to stores having merchandise that might be injured by sulphur fumes, as tobacco, sugar, flour, etc. Despite the popular fear of hydrocyanic-acid gas there is no danger if ordinary precautions are taken to properly seal the building. The gas is generated by mixing 1 part cyanide of potash (C. P.), 1 part of sulphuric acid (C. P.), and 3 parts of water. The receptacles should be durable earthenware jars or lead-lined pails. The water and acid are first mixed and the cyanide in a paper bag is added at the last moment. By placing the cyanide in a thin paper sack before dropping it into the acid solution, the chemical action is sufficiently delayed to give the operator opportunity to leave the room and seal the door of egress.

One ounce of the cyanide is sufficient for each 100 cubic feet of air space, but the efficiency of fumigation can be controlled by placing captive fleas in a test tube within the room and rats in cages well protected by loose covering to simulate natural harborage. A small amount of dust in bottom of the test tube will simulate natural conditions for fleas.

A 12-hour exposure to sulphur fumes or 4 hours of hydrocyanic acid gas will be effective in destroying rats and fleas within the inclosure.

Following this treatment and after the fumes have been dissipated, rat harborage should be removed, double walls, double ceiling, plank floor, etc., and all surfaces drenched with a pulicidal solution. The use of germicides, such as coal tar derivates, corrosive sublimate, carbolic acid or formalin solutions, is a waste of time. Crude kerosene or a kerosene emulsion are both efficient in destroying fleas. The emulsion is prepared by the combination of 85 parts kerosene and 15 parts of a hot solution of soap. This emulsion is used in the strength of 2 per cent in water.

Where there has been a plank flooring the ground beneath should be drenched with coal oil or the emulsion. Care must be exercised to prevent escape of rats. Frequently when raising a floor no rats are seen, but if all the ground is dug up to a depth of 2 feet quite often rats will be excavated from burrows. It is the rule that rats will not be found exposed beneath the covert, but will have made burrows to a depth of 1 or 2 feet. A cordon of laborers with clubs should be stationed about to kill escaping rodents. When rat runs extend into rocky formation or other material difficult to destroy, the use of carbon disulphide ($CS_2$) vapor or acetylene can be attempted, the former by pouring into the burrow with or without ignition, and the latter by placing a piece of calcium carbide, water being added, and the entrance to burrow being thoroughly occluded afterwards.

Rat-proofing plague-infected buildings is a further aid to flea and rat destruction when the procedure immediately follows removal of harborage. A concrete floor and walls effectually seals within existing burrows all fleas, flea eggs, or rats that have not been unearthed and destroyed.

When plague infection is discovered in any premises, all domestic pets should either be killed or very thoroughly treated with pulicidal baths.

### Procedures of Minor Value or Doubtful Efficiency.

The argument that certain measures are justifiable on the ground that "even if they do no good they do no harm" is fallacious. Every effort exerted toward an inefficient measure detracts just that much from a more vigorous prosecution of the essential and necessary work. So it is of no little importance to discriminate between the effective and the irrational measures.

*Disinfection.*—Of all the useless procedures the most common is that of widespread disinfection, the employment of vile smelling germicidal solutions, liberally sprinkled on the streets, sidewalks, and in public places, everywhere but the places that rodents frequent. The extensive use of pulicidal solutions is advisable, even though they may not always be applied in the most advantageous places.

The indiscriminate use of germicidal solutions is merely a survival of the old habit of the pioneer sanitarian in using disinfectants on all occasions as a "votive offering to unknown gods." The writer once had opportunity of observing the efficiency of a 10 per cent creolin solution. The space treated was the ground area of a store subsequent to the removal of flooring. The entire area was thoroughly drenched by means of a hose and force pump. Forty-eight hours after the treatment the fleas were apparently as thick as ever.

*Isolation of cases.*—The isolation of a plague case is necessary because of the necessity of fumigating the infected building, clothing, etc., but enforced hospitalization is not justifiable nor essential when a neighbor's or relative's house is available for the reception of the case.

*Contacts.*—The isolation of contacts is of very questionable value and can only be considered on the assumption that such contacts might be carriers of infected fleas. Personally the writer has never seen infection so transmitted. It entails no small strain on one's credulity to conceive as possible the transmission of infected fleas in the clothes of a contact who himself remains free of the disease to a third person who contracts the disease. The Indian Plague Commission considers such a condition possible.

*Destructive measures.*—General destructive measures, especially by the method of "burning up" an entire district, are not necessary, though such procedure is spectacular and greatly impresses the people

In a small village of shacks the touch of a torch may be the most practical solution for removal of rat harborage, but where property value to an appreciable amount is involved rat proofing with allied measures will accomplish just as much in an eradicative way as will fire. Indiscriminate burning only scatters the rats, for the incineration of the above-ground structure will not destroy rats or fleas that remain in burrows 1 and 2 feet below the ground surface. When fire is employed as the ''cleansing'' agent, the area should be encircled with an impervious stockade (galvanized iron sunk into the ground) or a water-filled moat with a cordon of men to prevent rodent escape.

Subsequent to the conflagration the entire area must be dug up to the depth of 2 feet and saturated with pulicidal solution.

*Vaccination.*—Vaccination is in no sense an eradicative measure, nor is it a preventive one as pertaining to rodent plague; as a therapeutic agency in producing immunity to plague infection there does not seem to be any widespread faith in its efficiency. Regardless of the effectiveness of plague vaccines, the most enthusiastic supporter of the practice can not claim for the procedure more than the advantage of personal prophylaxis, and plague eradication has a wider scope than the consideration of the individual.

*Rat holes.*—Another practice that would seem to require the expenditure of time, labor, and money out of all proportion to the benefits secured is that of stopping up rat holes in material pervious to the passage of rats.

If a burrow is so treated the rodent burrows around the occluding plug during the night; if the rat hole is in planking and occluded by tacking over it a piece of tin, the rat harborage beneath the planking is in nowise disturbed, and at its leisure the rat will gnaw another hole in the wood.

In conclusion, it can be said that the foregoing is merely a general expression of the different lines of endeavor a sanitarian may adopt in combating plague. Conditions will vary according to the climate and the social condition and mental attitude of the affected community toward the enforcement of eradicative measures.

To assure compliance with any law, there must be a certain amount of supporting opinion in the community. The success of eradication will depend largely on the extent of cooperation of the citizens.

Measures that may be the only logical procedure in one community may prove impracticable in others. In general, the sanitarian will have to work out his own salvation in the matter of details, and it is in the careful execution of details that success depends.

Attached hereto is a synopsis of which the preceding article is an elaboration.

## Conclusion.

In conclusion, it can not be too strongly stated or too often reiterated that the ultimate object of plague eradication is the destruction of the *last* plague rodent with its infected parasites. The elimination of human plague incidence is, from an eradicative viewpoint, merely incidental. True, it is of relative value as indicating the decline of rodent infection, but in nowise can the subsidence of human cases be considered as the criterion of a successful campaign.

When can a community be considered free of plague infection? The answer is difficult and depends upon various factors.

The duration which rodent plague can remain quiescent or at least confined to rats is probably proportional to the size of the community, the infection remaining dormant for a longer period of time in large cities than in small towns. In Habana, Cuba, some 20 months elapsed between the last human case of the initial epidemic (July 14, 1912) and the first case of the recrudescence (Mar. 1, 1914). In Seattle, Wash., many months have elapsed between the discovery of plague rats. Another factor entering into the question is the effectiveness of laboratory examination in detecting plague rats. When, from the inception of the epizootic, plague-infected rodents have been reported in sufficient numbers as to give faith in the rodent survey, considerable dependence can be placed upon the negative laboratory reports. If there have been very few or no plague rats detected in the routine examination of rodents, it is obvious that continued negative reports from the laboratory are of little value.

The reduction of rodent population, the extent of rat proofing, and the improvement in general sanitary conditions all enter into the question of determining the eradication of plague infection.

If the rat proofing has been thorough, the rodent population diminished 50 to 75 per cent, and rat examination has been dependable, it would seem that a community can be reasonably considered free of the infection one year after the last plague rat has been reported. After such a period the eradicative measures can be limited to a reduced force of trappers. Once plague has gained entrance to a community it is advisable to maintain a force of trappers and rodent examination as a permanent part of the health organization. With the world-wide prevalence of plague a force of trappers, in conjunction with a laboratory examination of all captured rodents, ought to be a part of the permanent sanitary force of every seaport having trade relations with infected countries.

*Outline of plague eradication.*

- General measures
  - Survey
    - Plague laboratory diagnosis.
      - Human plague.
      - Rodent plague.
    - Demarcation of infection.
      - Rodent examination.
      - Epidemiology of human cases.
      - "Sentinel" guinea pigs or rats.
  - Eradication
    - Rodent destruction
      - Trapping.
      - Poisoning.
      - Miscellaneous.
    - Rat proofing
      - Food supplies.
      - Elimination of harborage.
  - Restrictive
    - Fumigation by $SO_2$ or HCN.
      - Ships.
      - Freight.
      - Baggage.
    - Rat proofing and supervision.
      - Railroad cars.
      - Stations.
- Special measures (applied to plague foci).
  - Evacuation.
  - Intensive rodent destruction.
    - Summary destruction of harborage.
    - Fumigation
      - HCN.
      - $SO_2$.
      - $CS_2$.
      - $CaC_2$.
  - Flea destruction
    - Kerosene.
    - Kerosene emulsion.
    - Fumigants
      - HCN.
      - $SO_2$.
    - General cleanliness.
    - Attention to household pets, cats, and dogs.
- Procedures of minor value or doubtful effectiveness.
  - General destructive measures.
  - Hospitalization of human cases.
  - Quarantine of personnel.
  - Vaccination.
  - Disinfection.
  - Stoppage of rat holes.

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## STANDARDS FOR MARKET MILK.

### THEIR ESTABLISHMENT AND RECOGNITION NECESSARY FOR THE CONTROL OF THE PRODUCTION AND SALE OF MILK IN THE INTERESTS OF THE COMMUNITY.

In the Public Health Reports of May 10, 1912, there was published the report of the Commission on Milk Standards appointed by the New York Milk Committee. The commission was a voluntary organization composed of men from various parts of the country. They were appointed to draft standards by which market milk could be suitably classified, such a classification being desirable in the interests of the producer, the purveyor, and the consumer.

The handling of any article for sale is on a satisfactory basis only when it can be judged by standards understood by both the one who sells and the one who buys. This is especially so when the article is a foodstuff of such general use and so intimately related to the spread of disease as milk.

A revised report of the Commission on Milk Standards was published in the Public Health Reports of August 22, 1913. The standards recommended by the commission in this report have been indorsed by the conference of State and provincial boards of health (June 19, 1914) and the American Medical Association (Atlantic City meeting, June 22-26, 1914).

In the Public Health Reports of May 15, 1914, there was published a tabulation of the bacteriological standards for milk adopted by